

CHAPTER 6

Buried Transuranic Waste

6.1 Background

From the 1940s through the 1970s, radioactive waste meeting the current definition of transuranic (TRU) waste¹ was disposed of by shallow land burial and other techniques at a number of sites owned and operated by the federal government in support of the nuclear weapons program. The U.S. Atomic Energy Commission (AEC) first identified TRU waste as a separate category of radioactive waste in 1970. In 1973, the AEC further defined TRU waste as waste containing more than 10 nanocuries per gram (nCi/g) of TRU alpha-emitting radionuclides. This waste was believed to warrant more stringent handling and disposal considerations than low-level waste (LLW) because of the hazards associated with the increased concentrations of long-lived alpha-emitting radionuclides. The U.S. Department of Energy (DOE) revised the definition of TRU waste in 1982, increasing the lower limit of TRU alpha-emitting radionuclides with half-lives greater than 20 years to 100 nCi/g.

According to the Immediate Action Directive issued by AEC in 1970, all TRU waste generated after 1970 was to be segregated from LLW and placed in retrievable storage pending shipment to and disposal in an approved geologic repository. Three sites, Los Alamos National Laboratory, Oak Ridge Reservation, and Savannah River Site, continued to bury some TRU waste well into the 1970s. While the intent of these burials may have been retrievable storage, most of this waste is now considered essentially irretrievable. Other than the waste burials at these three sites in the 1970s, all TRU waste generated since that time has been placed in retrievable storage. Some waste managed by shallow land burial or placed in retrievable storage between 1970 and 1982 as TRU waste is now considered LLW because it contains TRU alpha-emitting radionuclides in concentrations between 10 and 100 nCi/g.

To improve the quality of information on buried TRU waste, the DOE compiled updated information in 1999 for previously-disposed TRU waste. The information provided by the DOE Field Offices on this waste was entered into the *Buried Transuranic-Contaminated Wastes and Related Materials Database* (referred to herein as the buried TRU waste database). In this data update activity, the term "TRU-contaminated" was used to refer to materials (waste and contaminated environmental media) containing TRU alpha-emitting radionuclides in concentrations greater than 10 nCi/g. These materials were divided into two categories: "TRU" materials, which have concentrations of TRU alpha-emitting radionuclides above 100 nCi/g (consistent with the current definition of TRU waste) and "αLLW" ("alpha low-level waste") materials, which have concentrations of TRU alpha-emitting radionuclides between 10 and 100 nCi/g.

The DOE prepared a document summarizing the information from the buried TRU waste database and other related reports to provide a single source of updated information on buried TRU-contaminated materials. This report, *Buried Transuranic-Contaminated Waste Information for U.S. Department of Energy Facilities*² (referred to herein as the buried TRU waste report), was issued in June 2000 and is available in PDF format on the Central Internet Database (CID) website.³ The information in this chapter is summarized from the buried TRU

¹ The DOE defines TRU waste as radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years. The term "transuranic" means those elements with an atomic number greater than that of uranium (i.e., atomic number > 92). (DOE Order 435. 1, issued July 1999).

² U.S. Department of Energy, Office of Environmental Management, *Buried Transuranic-Contaminated Waste Information for the U.S. Department of Energy Facilities*, (June 2000).

³ Directions on how to access the report through the CID are located in the box "About the Data..." on page 6-5.

waste report. The radioactivity information (curies of TRU radionuclides) in the buried TRU waste database was converted (decay-corrected) to the year 2006 to present information in a consistent manner for all sites. The year 2006 was chosen because this is the earliest year in which these materials could be scheduled for disposal at the Waste Isolation Pilot Plant (WIPP).

6.2 Overview

Certain radioactive waste disposed of by shallow land burial (generally prior to 1970) meet the current definition of TRU waste. This waste is considered to be buried TRU waste. As used here, buried waste is that which has been disposed of by shallow land burial generally within the top 30 meters (100 feet) of the earth's surface, consistent with guidance of the U.S. Nuclear Regulatory Commission for near-surface disposal of LLW given in 10 CFR 61. In addition to this buried TRU waste, certain radioactive waste meeting the current definition of TRU waste is disposed of by means that provide greater waste-isolation potential than shallow land burial, e.g., by hydrofracture disposal at the Oak Ridge Reservation and placement in shafts at the Los Alamos National Laboratory and the Nevada Test Site at depths generally between 30 meters (100 feet) and 300 meters (1,000 feet) of the earth's surface. This waste is not considered buried TRU waste in a strict sense. However, an accounting of such TRU waste disposed of at intermediate depths, along with previously-disposed α LLW (as defined previously), was included in the buried TRU waste report (and summarized here) for completeness.

In addition to previously-disposed TRU-contaminated waste, some soils have become contaminated with TRU radionuclides in concentrations exceeding 10 nCi/g (and in some cases 100 nCi/g) as a result of past discharges of liquid waste onto the ground, spills of liquid waste, surface and subsurface nuclear weapons tests, and special test projects such as criticality experiments and safety testing of nuclear devices. Also, a largely unknown volume of soil in the vicinity of buried waste (generally interstitial soil between waste containers) may have become contaminated with TRU radionuclides as a result of past management practices (such as crushing drums after placement) and radionuclide migration from the waste. The soils contaminated by previous nuclear tests and liquid and solid waste management activities could be considered α LLW or TRU waste, depending on the level of contamination.

The total volume and TRU radioactivity of previously-disposed TRU-contaminated waste and soil is given in Table 6-1 and illustrated in Figure 6-1. This information is presented in more detail in Table 6-2. The total volume of buried TRU waste at DOE sites is approximately 126,000 cubic meters. A much smaller volume of TRU waste (about 11,000 cubic meters) has been disposed of at intermediate depths. The volume of previously-disposed α LLW is significantly larger than the volume of previously-disposed TRU waste, approximately 317,000 cubic meters. Essentially all of the α LLW (an amount greater than 313,000 cubic meters) is buried waste, with only 3,200 cubic meters disposed of at intermediate depths. A total of 407,000 curies of TRU activity is associated with this previously-disposed waste (397,000 curies in buried waste and 9,800 curies in waste disposed of at intermediate depths). The TRU activity associated with the α LLW is less than 10 percent of that in the buried TRU waste.

The volume of TRU soil is about 32,000 cubic meters (essentially all of which is associated with liquid discharges at the Hanford Site), and the volume of α LLW soil is about 12,000 cubic meters. These two volumes do not include the contribution of contaminated soil at the Oak Ridge Reservation, which was reported as being unknown, or the volumes of contaminated rock and debris associated with subsurface nuclear weapons tests. The TRU-contaminated soil volume of 44,000 cubic meters contains a total of about 33,000 curies of TRU activity. Soil proximate to buried waste is probably contaminated, but the volumes cannot be reasonably estimated at this time.

The radioactivity information presented here is limited to TRU radionuclides, i.e., the curie totals do not include any information for fission and activation products. In addition, the TRU radionuclides are generally limited to alpha-emitting radionuclides with half-lives greater than 20 years consistent with the current definition of TRU waste. However, the DOE Field Offices were given the flexibility to include additional radionuclides in responding to the data call, including uranium isotopes, plutonium-241 (which has a half-life of 14.4 years and decays by emission of a beta particle) and curium-244 (which has a half-life of 18.1 years).

All of the TRU-contaminated materials reported here are solid; no liquid waste or waste water are included. While the buried TRU waste report does not include physical form data of the type given in the CID, this information is easily developed based on the descriptions of the materials in the database. A summary of the physical forms of the TRU-contaminated materials addressed here is given in Table 6-3 and presented graphically in Figure 6-2. Additional information on this TRU-contaminated waste and soil are given in the following sections.

6.3 Previously-Disposed TRU-Contaminated Waste

There are two categories of previously-disposed TRU-contaminated waste: buried waste, i.e., waste disposed of by shallow land burial in trenches and pits, and waste disposed of at intermediate depths to provide for greater waste isolation potential. These waste categories are discussed in Sections 6.3.1 and 6.3.2, respectively.

6.3.1 Buried Waste

Information on buried TRU-contaminated waste is given in Table 6-2. As indicated in this table, the Hanford Site has the largest volume of buried TRU waste of the six sites, with a total of 75,800 cubic meters containing 60,000 curies of TRU activity. (This total excludes volumes of α LLW, waste disposed of at intermediate depths, and contaminated soil.) This waste is associated with burial grounds previously used to dispose of radioactive waste at the site. Most of this waste is located in the Hanford Site's 200 West Area. The waste volume reported for the Hanford Site is limited to waste containing TRU radionuclides in concentrations greater than 100 nCi/g. Separate estimates of waste containing TRU radionuclides in concentrations between 10 and 100 nCi/g, i.e., α LLW materials, are not available for this site. Most of the materials are expected to be managed by in-situ containment, although a small portion may be retrieved for treatment and disposal.

The Idaho National Engineering and Environmental Laboratory (INEEL) has the next largest volume of buried TRU waste and the largest curie inventory, with a total of 36,800 cubic meters containing 297,000 curies of TRU activity. Much of this activity is associated with plutonium-241, a non-alpha-emitting radionuclide that decays to americium-241 with a 14.4-year half-life. The contribution of americium-241 (an alpha-emitting radionuclide with a half-life of 432 years) is included in the curie total. The volume given for INEEL represents waste having a concentration of TRU radionuclides in excess of 10 nCi/g, i.e., it represents the sum of the buried TRU waste and α LLW materials at this site. Separate estimates of the fraction of this waste containing more than 100 nCi/g are not currently available. A decision has not yet been made about future management of this waste, but in-situ technologies and excavation are under consideration. The remaining LLW that has a concentration of TRU radionuclides below 10 nCi/g is expected to be disposed of on site.

The Los Alamos National Laboratory and the Nevada Test Site contain lesser amounts of buried TRU waste: 8,620 cubic meters and 21 cubic meters, respectively. The Los Alamos National Laboratory also contains a large volume of α LLW materials (313,400 cubic meters) in four burial grounds at the Laboratory. The total TRU activities are 21,000 curies for the Los Alamos National Laboratory waste and 152 curies for the Nevada Test Site waste. In-situ containment of most of these materials is currently planned.

Volume estimates are not available for much of the TRU-contaminated waste previously disposed of at the Oak Ridge Reservation and the Savannah River Site. A reasonably good estimate of the TRU activity associated with the buried TRU-contaminated waste at the Savannah River Site is available (18,500 curies), but the activity associated with TRU-contaminated waste at the Oak Ridge Reservation is generally unknown. While in-situ containment is generally the preferred option for this waste, especially at the Savannah River

Site, the DOE may excavate certain buried TRU-contaminated waste at the Oak Ridge Reservation. On the basis of the results of this pilot excavation, additional buried TRU-contaminated waste may also be excavated. These remedial plans are considered preliminary and are subject to change. The buried TRU-contaminated waste volume at the Savannah River Site has not been examined in detail in recent years because the current plan is to continue to manage the previously-disposed waste in place.

6.3.2 Waste Disposed of at Intermediate Depths

Information for the TRU-contaminated waste that has been disposed of at intermediate depths in shafts, boreholes, and by hydrofracture techniques is also given in Table 6-2. The TRU-contaminated waste was disposed of by these techniques at three sites: the Los Alamos National Laboratory, the Nevada Test Site, and the Oak Ridge Reservation. About 11,000 cubic meters of TRU waste (or less than 10 percent of the total volume of TRU waste disposed of by shallow land burial) has been disposed of by such techniques at these sites, with an additional 3,200 cubic meters of α LLW present at the Los Alamos National Laboratory and the Oak Ridge Reservation in the same disposal units. The largest volume of previously-disposed TRU waste is associated with the New Hydrofracture Facility at the Oak Ridge Reservation, which accounts for about two-thirds of the total. Most of the rest is attributable to waste in shafts in three Material Disposal Areas at the Los Alamos National Laboratory and five Greater Confinement Disposal shafts at the Nevada Test Site. About 9,800 curies of TRU activity are associated with this waste. All of this waste previously disposed of at intermediate depths is expected to continue to be managed in place.

In addition to this previously-disposed waste, two sites contain TRU-contaminated rock and debris as a result of previous nuclear weapons tests: the Los Alamos National Laboratory and the Nevada Test Site. While these materials are not previously-disposed TRU-contaminated waste, they do represent materials that have radiological characteristics similar to those of such waste and are discussed here for completeness. These volumes and radioactivities are not included in the tables and figures given in this chapter. A total of 4,400 cubic meters containing 2,480 curies of TRU radionuclides is attributable to underground experiments involving special nuclear material conducted in multiple shafts and chambers at the Los Alamos National Laboratory. This material is expected to be managed by in-situ containment. Although a volume estimate is not available for the amount of material associated with subsurface nuclear weapons tests at the Nevada Test Site, this material is estimated to contain a total of 217,000 curies of TRU radionuclides. Continued land use controls will limit access to this large volume of subsurface contaminated rock and debris.

6.4 TRU-Contaminated Soil

There are three general sources of TRU-contaminated soil: soil contaminated by previous liquid discharges, soil contaminated by above-ground nuclear weapons tests, and soil contaminated by its proximity to buried solid waste. Approximately 38,600 cubic meters of soil have been contaminated by liquid discharges at three sites: the Hanford Site, the Los Alamos National Laboratory, and the Oak Ridge Reservation. The Hanford Site contains the largest volume of contaminated soil (31,600 cubic meters), primarily associated with cribs, ditches, and trenches. This contaminated soil contains a total of 32,400 curies of TRU radioactivity. As for buried TRU-contaminated waste at the Hanford Site, information is limited to soil containing TRU radionuclides in concentrations exceeding 100 nCi/g (i.e., TRU soil). No estimates of α LLW soil are available for the Hanford Site. The current expectation is that these contaminated soil sites will be managed by in-situ containment. The TRU-contaminated soil volumes and TRU activities for the Los Alamos National Laboratory and the Oak Ridge Reservation are significantly lower, although specific estimates are generally lacking for the Oak Ridge Reservation. The volume of TRU soil at the Los Alamos National Laboratory is 162 cubic meters and the volume of α LLW soil is 6,840 cubic meters; this soil contains about 10 curies of TRU activity and is expected to be managed by in-situ containment, although other alternatives are being considered. The TRU-contaminated soil in seepage beds and trenches at the Oak Ridge Reservation contains a total of 53 curies of TRU activity. Immobilization of the high-activity fission product residues in the seepage beds and trenches is currently planned. This process would also permanently immobilize any TRU-contaminated residues within the treatment zone.

Above-ground safety and nuclear weapons tests at the Nevada Test Site have resulted in contaminated soil covering an area of six hectares (15 acres) to an average depth of eight centimeters (three inches). The volume of this α LLW soil is estimated to be 4,800 cubic meters and to contain 86 curies of TRU activity. These values represent soil contaminated with TRU radionuclides in excess of 10 nCi/g. This soil is scheduled for excavation and disposal as LLW at the Nevada Test Site. Two of the five main locations have already been excavated and resulted in the generation of less than one cubic meter of TRU waste.

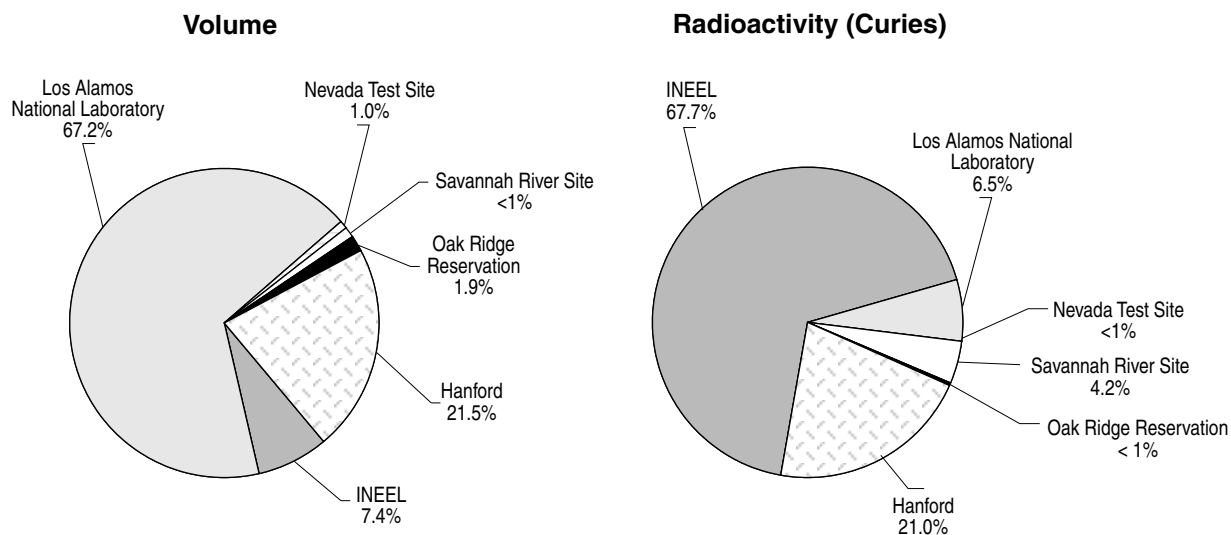
While the DOE Field Offices were able to provide estimates of the volumes of TRU-contaminated soil associated with liquid releases and above-ground nuclear weapons tests, they were not able to provide such estimates for contaminated soil in proximity to buried waste. It is somewhat easier to develop volume estimates for TRU-contaminated soil associated with liquid and atmospheric releases than for that associated with solid waste. The radionuclide inventories associated with previous releases are reasonably well known, so a volume estimate can be developed by measuring or modeling the extent to which these released contaminants have migrated in the environment. The contaminated soil is generally very accessible, especially for surficial soil contaminated by previous above-ground nuclear weapons tests, making direct measurements a relatively straightforward task. However, similar measurements for solid buried waste can be quite difficult due to the general inaccessibility of the contaminated soil. In addition, modeling approaches are difficult because of the heterogeneity of the waste and because the evaluations require estimating the release and movement of contaminants from intact or degraded waste containers located beneath any engineered covers that might be present.

About the Data in This Chapter

- The source of the data on buried TRU waste volume and radioactivity is the buried TRU waste report: U.S. Department of Energy, Office of Environmental Management, *Buried Transuranic-Contaminated Waste Information for U.S. Department of Energy Facilities*, (June 2000).
- *Note:* Unlike TRU waste and other waste types, it is not possible to run specific buried TRU waste data reports in the Central Internet Database (CID). However, the DOE report on buried TRU waste is available as a linked file through the CID. To access the DOE report on buried TRU waste, go to <http://cid.em.doe.gov> and look for the buried TRU waste option under "Standard Reports."

6.5 Previously-Disposed TRU-Contaminated Waste Data

Figure 6-1
Sites' Relative Contributions to the Volume and Radioactivity of
Previously-Disposed TRU-Contaminated Waste and Soil



Notes:

- The total volume of TRU-contaminated waste and soil is approximately 497,000 cubic meters, consisting of 169,000 cubic meters of TRU waste and soil and approximately 328,000 cubic meters of αLLW and soil. A total of approximately 439,000 curies of TRU radioactivity is associated with this material. See Tables 6-1 and 6-2 for more information.

Table 6-1
Summary of Total Volume and Radioactivity
of Previously-Disposed TRU-Contaminated Waste and Soil
 (Table 6-2 provides more detailed information)

State	Site	Site Code	Volume (cubic meters)	% Total Volume	Total Radioactivity (curies)	% Total Radioactivity
ID	Idaho National Engineering and Environmental Laboratory	INEEL	36,800	7.4	297,000	67.7
NM	Los Alamos National Laboratory	LANL	334,000	67.2	28,500	6.5
NV	Nevada Test Site	NVTS	4,920	1.0	579	<1
SC	Savannah River Site	SARS	4,530	<1	18,500	4.2
TN	Oak Ridge Reservation	ORTN	9,390	1.9	2,020	<1
WA	Hanford Site	HASI	107,000	21.5	92,400	21.0
Total			497,000	100	439,000	100

Notes:

- Volume and curie data are given to three significant digits.
- Data include α LLW.
- Additional information on these data can be obtained from the document identified below.
- Due to data rounding, the totals in this table may not equal the exact sum of the site-specific data.

Source: U.S. Department of Energy, *Buried Transuranic-Contaminated Waste Information for U.S. Department of Energy Facilities*, (June 2000).

Table 6-2
Total Volume and Radioactivity
of Previously-Disposed TRU-Contaminated Waste and Soil

			Buried TRU Waste			Waste Disposed of at Intermediate Depths			Contaminated Soil		
			Volume (cubic meters)		TRU Activity (curies)	Volume (cubic meters)		TRU Activity (curies)	Volume (cubic meters)		TRU Activity (curies)
State	Site	Site Code	TRU	α LLW	Decay-Corrected to 2006	TRU	α LLW	Decay-Corrected to 2006	TRU	α LLW	Decay-Corrected to 2006
ID	Idaho National Engineering and Environmental Laboratory	INEEL	36,800	NA	297,000	-	-	-	-	-	-
NM	Los Alamos National Laboratory	LANL	8,620	313,400	21,000	3,690	1,300	7,470	162	6,840	10
NV	Nevada Test Site ^a	NVTS	21	-	152	95	-	341	-	4,800	86
SC	Savannah River Site	SARS	4,530	NA	18,500	-	-	-	-	-	-
TN	Oak Ridge Reservation ^a	ORTN	570	NA	6	6,880	1,940	1,960	NA	NA	53
WA	Hanford Site	HASI	75,800	NA	60,000	-	-	-	31,600	NA	32,400
Total			126,000	313,000	397,000	11,000	3,200	9,800	32,000	12,000	33,000

Notes:

- Information is given to three significant digits.
- Additional information on these data can be obtained from the document identified below.
- Hyphens indicate volumes or activities of zero.
- Due to data rounding, the totals in this table may not equal the exact sum of the site-specific data.
- NA = not available.

^a The buried waste volumes and activities reported for NVTS and ORTN are for disposal site locations where definitive estimates are available and were provided in response to the data call.

Source: U.S. Department of Energy, *Buried Transuranic-Contaminated Waste Information for U.S. Department of Energy Facilities*, (June 2000).

Table 6-3
Summary of Total Volume of Previously-Disposed
TRU-Contaminated Waste and Soil by Physical Form

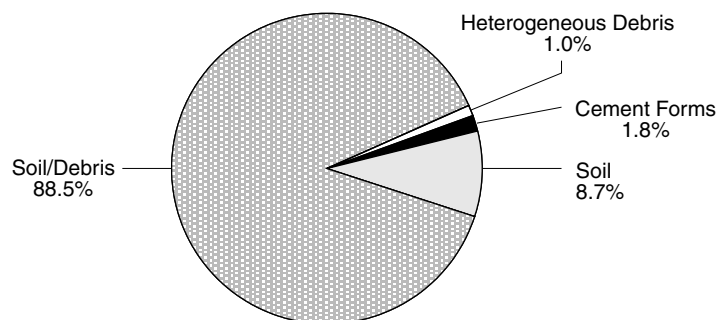
In cubic meters

Physical Form	Form Code	Volume	% Total
Cement Forms	Z1110	8,820	1.8
Soil	S4100	43,400	8.7
Soil/Debris	S4200	440,000	88.5
Heterogeneous Debris	S5400	5,090	1.0
Total		497,000	100

Note:

- Information is given to three significant digits.

Figure 6-2
Percent of Previously-Disposed TRU-Contaminated
Waste and Soil by Physical Form



Note:

- The total volume of TRU -contaminated waste and soil is approximately 497,000 cubic meters, consisting of approximately 169,000 cubic meters of TRU waste and soil and approximately 328,000 cubic meters of α LLW and soil. A total of approximately 439,000 curies of TRU radioactivity is associated with this material. See Tables 6-2 and 6-3 for more information.